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SALTPETRE.

(NITRE, POTASSIUM NITRATE.)

[*Dictionary of Economic Products, Vol. VI., Pt. II., S. 681-704.*]

A REPORT ON THE MANUFACTURE AND COMPOSITION OF INDIAN SALTPETRE, BY DAVID HOOPER, F.I.C., F.C.S.

Introduction.

The Inspector General of Agriculture in India in 1902 instituted an enquiry regarding the distribution of nitre deposits in India and the methods of manufacture adopted in separating and refining the salt. This was undertaken to show ways and means of reducing the cost of this salt so as to permit of its being used more extensively as manure either as crude saltpetre or in a purer form. The following notes on the subject are drawn up from observations made in the saltpetre-bearing districts, and from information obtained from officers of Salt, Revenue and Agricultural Departments.

It is desirable first to explain the process of nitrification with special reference to this country. The districts where nitre earths occur and where the salt is manufactured are then enumerated. The manufacture of saltpetre is described, and tables are given of the analyses of numerous samples of nitrous earth, crude and refined saltpetre, impure and purified table salt and other by-products.

Nitrification.

Nitrification.

It has long been known that when animal and vegetable matters containing nitrogen decay in earth impregnated with wood-ashes or lime, nitrates of potash and lime are formed. In warm climates especially there are numerous localities where the soil is highly charged with nitrates. This is not only true of India but of Egypt,

Nitrification. Poland, Hungary, Italy, Turkey, Burma, Tibet, Turkistan, Sumatra and Brazil. In each of these countries earths occur which are rich enough in saltpetre to pay the cost of working. In all these places the nitrate of potash appears to have resulted from the decomposition of organic remains, and is found chiefly on the sites of former habitations. The water of wells in crowded cities usually contains nitrogenous compounds originating from the soil and subsoil being contaminated with sewage and other nitrogenous organic matter. The nitrification occurs in the surface soil in contact with air and in the presence of an alkaline base such as lime, magnesia, potash, or soda. Usually there is enough carbonate of lime in soils to promote the action. Schlossing, performing some careful experiments in this subject, found that ammonia mixed with moist loam changed completely into nitrates in a fortnight. The processes of nitrification are caused by microscopic organisms termed bacteria or bacilli. One class of bacteria, according to Winogradsky, converts the ammonia into nitrous acid and are called nitrous ferments, and the other changes nitrous acid into nitric acid and are termed nitric ferments.

The following are some of the more important conditions favourable to the work of the nitrifying bacteria :—

Temperature. (*a*) *Temperature.*—The formation of nitrates becomes active at 54° F., and increases as the temperature rises above that point until it reaches 98° to 99° when nitrification is at its maximum. Under suitable conditions, other things being equal, 10 times as much saltpetre can be obtained at 99° as at 54°.

Moisture. (*b*) *Moisture.*—Water is indispensable in the formation of nitrates. Drought will retard the process, and severe drought stop it. Absence of rain for two or three seasons in certain Panjab saltpetre districts has caused a short supply. Water conveys the potash and lime bases to the scene of action where the bacteria are at work. It holds saltpetre and other salts in solution, and as it evaporates throughout the hot season brings these salts to the surface of the soil.

Oxygen. (*c*) *Oxygen*—Is essential, hence air must gain free admission to the surface soil as the process goes on. In the refineries the caking mud caused by throwing the dissolved by-products on the earth is broken up to allow of sufficient aëration.

Darkness. (*d*) *Darkness*—Is believed to be favourable for the formation of saltpetre. In manufactory yards in India the nitre earth is kept in sheds ; this is not only to keep off the rain but the

refiners believe that darkness produces a better yield of saltpetre.* Nitrification.

(*e*) *Calcium Carbonate* or lime aids the process. It was found present in all the samples of nitrous earths recently examined, and in considerable quantity in some samples. Lime.

Indian Nitre-bearing localities.

The districts where nitre or saltpetre is chiefly found occur in the Indo-Gangetic tract, which is identical with the geological region known as Indo-Gangetic alluvium. Beyond the Indus, in the Panjab, nitre is obtained from Bannu and Dera Ghazi Khan. Between the Jhelum and the Sutlej it is derived from Shahpur, Gujrat, Multan, Gujranwala, Montgomery, and Lahore, and on the other side of the Sutlej in Gurgaon and Karnal, at Hissar, Rohtak, and Delhi. In the United Provinces of Agra and Oudh it is found in the districts of Farukhabad, Mainpuri, Aligarh, Budaun, Hardoi, Meerut, Mutra, Etah, Etawah, Agra, Jalaun, Cawnpore, Hamirpur, Fatehpur, Allahabad, Benares, Ballia, Gorakhpur, Azamgarh, Mirzapur and Ghazipur. In Bengal it occurs chiefly in the Bihar districts of Saran, Champaran, Muzaffarpur, Darbhanga and Monghyr. Kashmir and the Native States of Patiala and Rampur furnish small supplies. It has also been collected in the Chanda districts of the Central Provinces, in the Ahmedabad and Kaira districts of Bombay, in Sind, in Bhino Jwargan in Central India, and in parts of the Deccan. Small quantities occur in Coimbatore, Kistna, and Trichinopoly in the Madras Presidency. In Burma saltpetre has been manufactured between Pagan and Ava on the Irrawaddy, and in the Southern Shan States. (*Ind. Forester*, XXVII, 1901, 582.) Nitre-bearing localities.

The formation and composition of nitrous earth.

In the places where the nitrous earth is collected the natural vegetation is scant.† The soil of the more open parts is too salt for agricultural crops even in the rains. Nitrous earth to a considerable extent is obtained from places which could not be cultivated. It is obtained in and around existing village sites and on mud walls which enclose the dwelling places and cow-sheds of the village. In the rainy season, lasting from June to October, the process of nitrification Formation of nitrous earth.

* Heat of the sun is necessary for the formation of saltpetre. In manufactory yards in India the nitre earth is kept in sheds to prevent the saltpetre from being washed out of it by heavy rainfall. After the monsoon the nitrous earth is brought out of sheds and its cultivation is carried on in the open air. In districts of heavy rainfall like Bihar the nitrous earth is kept under shelter. (*Comr., N. I. Salt Rev.*)

† The nitre-bearing land at Hansi produces the *ak* (**Calotropis procera**), *karil* (**Capparis aphylla**) and the Mexican poppy (**Argemone mexicana**). It is of interest to notice that Mr. J. O. Schlotterbeck has recently made a chemical investigation of the Mexican poppy in America and he reports (*Journ. Amer. Chem. Soc.* 24,242) that potassium nitrate is present in the ash of the plant in notable quantity.

Nitrous earth.

goes on in the warm moist surface soil, to which conservancy refuse and other nitrogenous organic matter has been added. The soil's natural supply of necessary inorganic bases is increased by the people throwing fuel ashes outside their dwellings. During the dry season, commencing in November, the soluble products of the nitrifying bacteria rise to the surface by capillary attraction. This nitrous earth differs from the white *reh* efflorescence so commonly seen in the United Provinces and the Panjab. It is of darker colour, and if scratched with a nail or knife white specks of nitre crystals are visible to the naked eye, and the earth, if placed on the tongue, has a cool, saline taste. This incrustation with the soil to the depth of half an inch is the nitrous earth or *lunamati* or *militshora* of Indian saltpetre manufacturers.

Composition of nitrous earth.

Analyses of the nitrous soils of the Hathwa Raj, Bengal, were made from month to month from February to May and were found to have a similar composition. This indicates that in this district the constituents remain the same during the continuance of the dry weather. Another series of analyses was made of soils taken at various depths immediately after the rainy season. A complete analysis being made of each sample, it was shown that the soluble salts, of which potassium nitrate was the most abundant, existed in a larger amount above 6 inches below the surface of the earth. The nitrates rise to the surface after a short time, but at the depth of 12 inches at two different sites there was no indication of nitrates and an almost entire absence of other soluble salts. Lime and phosphoric acid were noticeable in all the soils, but organic matter and ammonia were in small amount.

The two sub-joined columns give the analyses of nitrous soil from Bengal. The first was made by the author and the second by Drs. Boekhout and Otto de Vries, of the Rijkslandbouwprefstation, Hoorn, Holland.

Water	9·04	3·3
Organic matter	6·22	·5
Iron oxide	3·52	4·0
Alumina	3·82	8·0
Lime	5·67	9·7
Magnesia	·86	...
Potash	1·87	1·0
Soda	1·26	1·7
Phosphoric acid	·22	·26
Sulphuric acid	·97	2·3
Chlorine	·30	·8
Nitric acid	2·00	*
Carbonic acid	3·83	...
Silica and sand	60·40	50·8

* Total nitrogen 0·29 (Jodlbaur), 0·30 (Dumas), nitric nitrogen 0·22, albuminoid nitrogen 0·08 per cent.

Nitrous earth.

Seventy-two samples of nitrous earth were chemically examined. The results are exhibited in tabulated Statement I which discriminates between various classes of samples. The composition of the samples is exceedingly variable. The salt consist of nitrates, nitrites, chlorides and sulphates of potassium, sodium, magnesium and calcium. They have an alkaline reaction, and in a few cases evolve a slightly ammoniacal odour. The two samples, Nos. 96 and 97, from Cawnpore, and one, numbered 421, from Lahore, were not used for saltpetre making but for manures in gardens. Nitrous earth is not uncommonly used as manure in parts of the Panjab, United Provinces, Sind, and Bengal. The particular samples referred to are superior for nitre production to some others in the tabulated list, but could have only been economically used locally as manure. The cost of transport to any distance would have been prohibitive, as they only contained about half the amount of nitrogen found in ordinary samples of farmyard manure.

Valuation.

The total percentage of salts in the various samples varies from 36·22 to 1·49, whilst the percentage of nitrates varies from 22·57 to ·64. The true value of a nitrous soil to the saltpetre manufacturer depends more upon the quantity of nitrates in the salts than on the salts in the soil. An effort was made to obtain, from each locality, samples which in local opinion were considered good, middling, and inferior. These particular samples are grouped in the statement collectively. Actual analysis showed that in some cases local opinion was right, in other instances it was very wide of the mark. In the light of this evidence we are led to the conclusion that the value of nitrous earth cannot be estimated merely by its appearance.

As regards the earths from Okara in the Panjab, the local valuation was right. The samples yielded of potassium nitrate—

	Per cent.
Good	12·58
Middling	6·10
Inferior	3·81

In samples from Farukhabad, Bhawani, and Sirsa the supposed superiority is attributable more to the abundance of the saline matter than to the yield of nitrates. As regards samples from other districts those which were classed as inferior or middling were actually found superior to those appraised as good.

There is clear evidence that the nitrous earths obtainable in some districts are of high value for the production of excellent saltpetre, and are very much superior to those found in other districts. Fuller enquiry is required to determine relative values in a reliable way, and also differences in value between samples of the same districts collected at various times during the manufacturing season.

Nitrous earth.

Samples 542 to 558, which form the fourth group of the tabular statement, were collected to throw light on the latter point, but the figures are contradictory and do not exhibit any progressive increase or decrease of value.

It should be noticed that nitrous earth frequently contains stones and pieces of broken pots, etc., owing to the fact that it is collected mostly from the sites of old habitations. The larger pieces are removed by the worker because they interfere with filteration. Samples 434 and 457 were of this class. The analyses 434 A and 457 A represent that of the finely sifted earth removed from the coarse impurities of the original samples.

Factory soil.

Samples 64 to 72 of the 5th and 6th groups of the statement represent "Refinery earth" or "Factory soil," and these should be distinguished from ordinary nitrous earth. The manufacturer spreads his exhausted nitrous earth in his yard, and on it are thrown from time to time the skimmings from the boiling saltpetre solution, such mother-liquor as can be spared or is supersaturated with inferior salts, the ashes from the fire-places, and all other waste products from the factory. These are absorbed by the soil of the yard which is stirred to secure admixture and aëration. The samples of factory and refinery earths were obtained from these yards. Some of the samples were collected in the open yards, others in closed sheds. They are naturally of variable composition.

STATEMENT I.—*Analyses of nitrous earths.*

Serial No.	Source of Sample.	Register No. of sample in the office of the Agricultural Chemist.	Nitrates of Potassium, Lime and Magnesium.	Chloride Sodium.	Sulphate Sodium.	Total Salts.	Nitrogen in Nitrates.	Remarks.
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
1	Cawnpore	96	3·60	1·99	1·95	7·54	·49	Nitrous earth directly used as manure.
2	"	97	2·29	2·85	3·60	8·74	·33	
3	Lahore	421	2·67	4·82	5·02	12·51	·45	
4	Shahawar, Etah, good	432	6·23	2·01	·97	9·26	1·00	Nitrous earths from various districts classed locally as good, middling, inferior, or 1st, 2nd, and 3rd quality.
5	" " middling	433	9·49	2·42	1·17	13·08	1·43	
6	" " inferior	434	1·17	·50	·50	2·26	·16	
7	" " "	434a	1·86	1·00	·78	3·64	·27	
8	Muttra, good	457	2·96	1·50	·90	5·36	·46	
9	" "	457a	6·04	2·73	1·29	10·06	·90	
10	" middling	458	6·65	5·35	·98	12·98	·97	
11	" inferior	459	9·08	4·20	1·32	14·60	1·33	
12	Sewan, Saran, good	649	7·11	3·85	·50	11·46	1·23	
13	" " inferior	650	2·80	1·33	1·45	5·63	·50	
14	Hardoi, quality I	871	4·68	4·35	4·05	13·10	·79	
15	" " II	872	7·68	7·06	3·98	18·72	1·22	
16	" " III	607	4·59	5·18	5·44	15·21	·80	
17	Farukhabad, quality I	672	7·48	11·67	10·17	29·32	1·27	
18	" " II	875	7·42	10·67	8·79	25·88	1·21	
19	" " III	673	3·32	4·22	5·24	12·78	·57	
20	Gurwa, Ghazipur, good	677	9·41	5·26	·59	15·26	1·58	
21	" " middling	678	13·95	4·48	2·15	20·58	1·30	
22	" " inferior	679	12·39	3·80	1·95	18·14	2·10	
23	" " good	683	2·01	1·03	1·36	4·40	·33	

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STATEMENT I.—*Analyses of nitrous earths.*

Serial No.	Source of Sample.	Register No. of sample in the office of the Agricultural Chemist.	Nitrates of Potassium, Lime and Magnesium.	Chloride Sodium.	Sulphate Sodium.	Total Salts.	Nitrogen in Nitrates.	Remarks.
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
24	Gurwa, Ghazipur, middling	684	4·59	4·34	·59	9·52	·76	Nitrous earth from various districts classed locally as good, middling, inferior, or 1st, 2nd, and 3rd quality.
25	" " inferior	685	·64	·14	·71	1·49	·11	
26	Okara, Montgomery, good	715	17·87	8·03	5·94	31·84	2·66	
27	" " middling	716	9·08	7·36	2·60	19·04	1·36	
28	" " inferior	717	9·60	10·15	3·73	23·48	1·56	
29	Bhawani " good	725	29·57	10·78	4·87	36·22	3·06	
30	" " middling	726	6·89	4·66	7·77	19·32	1·10	
31	" " inferior	727	3·73	4·17	5·04	12·94	·59	
32	Sirsa, Hissar, Panjab, good	733	6·66	6·84	4·40	17·90	1·02	
33	" " " middling	734	8·04	5·45	·65	14·14	1·23	
34	" " " inferior	735	4·53	1·82	1·45	7·80	·71	
35	Bhera, Shahpur, Panjab, good	740	13·08	14·26	6·46	33·80	2·28	
36	" " " middling	741	9·92	9·31	2·63	21·86	1·60	
37	" " " inferior	742	2·41	1·82	1·76	5·99	·41	
38	Muswanpur	381	6·93	2·24	·57	9·80	1·08	
39	Jajmou	383	2·75	2·21	2·62	7·58	·42	
40	Hansi	435	4·25	2·27	1·12	7·64	·70	
41	Hansi Castle	439	3·99	1·73	·60	6·32	·60	
42	Alinagar, Benares	690	6·53	2·66	·45	9·64	1·02	
43	Fatehpur	697	6·18	2·90	·92	10·00	1·00	
44	Bidakhar, Hamirpur	703	16·22	3·97	·41	20·60	2·51	

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45	Chaki, Jalaun	707	4·42	1·36	·20	5·98	·73	Ordinary samples of nitrous earths obtained from various districts. The first three samples represent good, middling, and inferior samples collected when season had fairly begun; the remainder collected in the same place at intervals during manufacturing season.
46	Mahgaon, Allahabad . .	709	3·42	1·85	1·29	6·56	·54	
47	Andakila, Saran . . .	747	1·69	1·30	·48	3·47	·20	
48	Lalganj, "	748	1·25	·69	1·56	3·50	·21	
49	Jahanabad, "	779	1·06	·26	1·45	2·77	·17	
50	Muzaffarpur	758	2·59	·98	1·43	5·00	·44	
51	Barhanpura, Muzaffarpur .	759	3·02	1·68	1·62	6·32	·49	
52	Dokra, " . .	760	·92	·60	1·23	2·75	·17	
53	Gujrat, Panjab . .	820	3·28	1·43	·65	5·36	·51	
54	Siripur, Saran, good . .	542	1·13	·70	·88	2·21	·18	
55	" " middling . .	543	1·21	·85	1·23	3·29	·19	
56	" " inferior . .	544	4·97	2·61	7·32	14·90	·90	
57	" " 1st February .	552	2·50	1·17	1·85	5·52	·41	
58	" " 15th " .	553	1·96	1·29	1·07	4·32	·29	
59	" " 1st March . .	554	2·22	1·58	1·68	5·48	·37	
60	" " 10th " . .	556	1·11	1·16	·78	3·04	·15	
61	" " 1st April . .	557	2·96	1·68	2·08	5·72	·48	
62	" " 16th " . .	557	2·11	1·45	1·52	5·08	·37	
63	" " 1st May . .	558	2·21	1·45	1·46	5·12	·36	
64	Dindialpur, refinery earth (closed shed).	654	4·80	4·14	·83	9·82	·72	
65	Dindialpur, refinery earth (soil from exposed yard).	655	8·85	6·43	3·68	18·96	1·44	Refinery earth collected in open yards and in closed sheds.
66	Barhanpura refinery earth (from yard).	761	5·32	3·35	6·88	15·73	·93	
67	Barhanpura refinery earth (from inside shed).	763	1·97	1·47	2·04	5·48	·32	
68	Kheora (1st Factory) earth .	389	3·06	2·84	2·86	8·76	·48	Ordinary samples of factory site earth.
69	" (2nd ") " .	395	13·47	8·03	3·32	24·82	2·06	
70	Hansi (Factory soil) . .	436	5·30	4·14	3·72	13·16	·71	
71	Shahzadpur, Allahabad (refinery).	710	4·26	2·49	2·75	9·50	·74	
72	Parsanni refinery earth . .	762	1·63	1·24	2·31	5·18	·27	

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Manufacture of crude saltpetre.

The Manufacture of Crude Saltpetre.

The preparation of crude saltpetre from nitrous earth consists of two distinct but simple processes. The first is the leaching or exhaustion of the saline matter by allowing water to percolate through the nitrous earth. The second is the evaporation of the liquor so obtained either by the agency of the sun's rays or by the employment of artificial heat. These processes are conducted in some districts of Bengal by a special caste of men called *Luniahs* or *Nuniahs*, but in parts of the United Provinces and the Panjab ordinary villagers of no special caste engage in the industry. In the neighbourhood of Hissar the crude nitre-makers are generally low caste *kumbhars* (potters) or other Hindus or Musalmans. They are occasionally called *shoragars* or nunaris.

Collecting the earth.

The season for collecting the nitrous earth lasts from November to the commencement of the monsoon. The surface of the soil is scraped off to a depth of half to one inch by means of the ordinary country spades (*kodali*). Some *Nuniahs* scrape the earth with broken tiles or pieces of earthen pot. The earth thus collected is made into heaps, or is taken direct to the factory in head-loads, or donkey-loads. Patches are scraped and the earth collected until the leased area is gone over. The process is repeated throughout the fine season at intervals which may range from 4 or 5 days to as much as a fortnight.

In a factory examined at Murwanpur, 4 miles from Cawnpore, the following arrangements were found. One boiling pan was at work, and the fuel consisted of dried leaves and stalks brought in head-loads by the wives of the workers. Six men were at work, and the nitrous earth was obtained from the walls of the village huts and compounds.

Leaching the earth.

The earth is stacked by the side of two oblong pits or filters (*kuria* or *kothi*) 7 feet long, 3 feet broad and 1 foot deep. They are placed end to end with an earthen *ghara* or jar (*nand*), 1½ feet in diameter, buried in the ground between them. The floor of the filter is made of puddled clay and is so arranged that the slope on either side is towards the central longitudinal line of the filter. This central line has a slope towards the outlet connecting with the jar. On the floor is laid a framework of small brushwood the sides of which rest on the clay and the cross-pieces of which are laid on top of the side-pieces. The filter is carefully packed with the nitrous earth, and water is then poured on the surface, which commences to trickle out in one hour or so as nitrous brine. After the first charge of water, more is poured on the surface until the brine trickling out appears to be too weak to work. The exhausted soil from the filters is then

Crude saltpetre.

taken out and thrown on a heap which gets large by the time the season ends. The liquid from the *nand* is baled out and transferred to an iron evaporating pan or boiler (*karahi*) which is supported on a brick fire-place. The boiler is 5 feet in diameter and is made up of iron sheets riveted together, and costs about R20. The liquor is boiled for about 7 hours or until it is sufficiently concentrated. To determine this a drop of the solution is taken and placed on the thumb nail. If crystals appear at once, the boiling is considered to be complete.

Crystallising

The hot boiled liquid is transferred to open vessels of rough pottery to cool and crystallise. The crystals will usually have sufficiently formed to be collected next morning. They are taken out and drained in baskets which act as filters, and then thrown into a pit in the ground where the crude saltpetre, or *kachcha shora*, as it is locally called, is stored.

Residues preserved.

The *Nunias* are careful not to lose any of the nitrates. The mother-liquor from each boiling is added to the fresh brine obtained from the filters, and the mixture is treated as above described. The mother-liquor after several boilings, becomes greatly saturated with salt. It is then thrown on the heap of exhausted earth which, after exposure to the air, again yields nitrous earth. The outturn of crude saltpetre from this factory came to about 78 maunds in the season, and was sold to a refinery at Cawnpore at R3 per maund of 82¾ lbs.

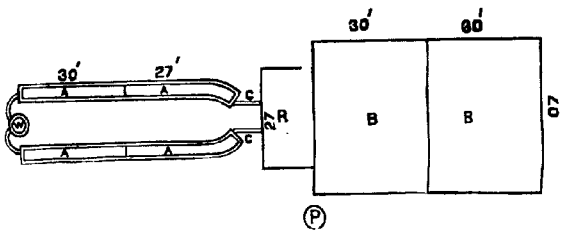
In Behar smaller boilers and sometimes earthen pots are used and the filters are round instead of oblong.

Evaporation by solar heat.

The method of making crude saltpetre by the heat of the sun is practised in the drier parts of the Panjab and in other provinces where the climate permits. The crystallising beds or pans used in this process are termed *pata*, and the resulting saltpetre or *abi shora* as it is called is not considered to be of such a good quality as *jaria shora* or crude saltpetre prepared by artificial heat.

Description of process.

A large quantity of *abi shora* is made annually at Hansi in the Hissar district, where personal enquiry into the industry during the hot weather of 1902 has made it possible to give a short description of the manufacture. The soil is collected at Hansi castle, an old ruin, the walls and moat of which supply nitrous earth, and the sum of R300 per annum is paid to Government for the privilege of collecting it. It is conveyed in donkey-loads to the factory which is situated by the side of a main road outside the town. The arrangement of the beds for leaching the nitrous earth and evaporating the nitre liquor is shown in the accompanying sketch :—



Crude saltpetre.

A A Beds or filters (*kurias*) for the filtration of the nitrous earth.
B B Beds (*patas* or *kiaris*) for evaporating the nitre liquor.
C C Channels to conduct the liquor to the evaporating beds.
R *Jhela* or reservoir.
P Pit for storing the saltpetre.
W Well for supplying water.

The *kurias* are 25 to 30 feet long, 6 feet broad, and 1 foot deep. There are two of these *kurias* which are sometimes sub-divided and arranged in two rows, running parallel, and situated on a broad hillock raised 3 or 4 feet above the ground. The beds are made of plastered clay or lime and are practically water-tight. The two evaporating beds are built on the level ground, and have concrete floors and sides. These are about 6 inches deep and 25 to 40 feet square. They communicate with one another, and the smaller bed, which is raised slightly above the larger ones and is nearer the mound, serves as a reservoir for collecting any nitre water that is not required by the other beds.

Evaporation by solar heat.

The salt earth is carried to the *kurias* and is packed in them to a height of about 8 inches. It is sometimes mixed with ashes in order that the soil may remain open and porous when the water is added, and possibly also with the object of decomposing the calcium and magnesium nitrate with the carbonated alkali. When the packing of the earth is complete, then water from the well (W) is baled up by earthen pots and poured over the nitrous soil and is allowed to filter slowly through it in order to dissolve the saline matter. The saturated liquor flows off in a small stream, through the concrete channel, into the large shallow evaporating beds. Meantime the other bed is filled as described with earth and water, and filtration and drainage go on regularly in rotation in the filters until enough liquor is obtained to fill the lower evaporating beds. The exhausted earth is removed from the *kurias* when the water extract has been fully drained off.

Crude saltpetre.

As the yellowish liquid in the evaporating beds becomes more concentrated the nitre begins to crystallise at the sides and bottom, and after about seven days most of the nitre has solidified and it is raked together into parallel ridges along the length of the bed about 3 feet apart. The mounds of crude crystals, after further drying, are collected together into heaps and then carried in baskets to a pit made in the ground a short distance off. The evaporating *kurias* are never allowed to become quite dry during the working season, in order to avoid cracking; as soon as the damp crystals are removed to the pits fresh nitre liquor is run in from the reservoir, and evaporation is continued. Each *kuria* is said to yield 20 to 30 maunds of crude nitre per week. The nitre prepared in this manner is placed in the storage pit until it is sold.

Composition of crude Saltpetre.

Composition of crude saltpetre.

The quality of crude saltpetre of commerce is considerably influenced by the quality of the nitrous earth from which it is made and the processes adopted for its manufacture. When artificial heat is employed for evaporation, impurities are removed by skimming and are also precipitated when the concentrated brine is allowed to settle before it is run into the crystallizing pans or vessels. Therefore the crude nitre is ordinarily purer than that produced by solar evaporation where nearly everything that is crystalline is collected. In the tabulated Statement No. II the analyses of 55 samples of crude saltpetre are given. The analyses are arranged in four groups, and the headings indicate the reasons for grouping. The amount of potassium nitrate ranges from nearly 80 per cent. in a sample (702) from Hamirpur to 26·8 per cent. in an inferior sample from Okara, the average percentage of 53 predominating. The chief impurity in crude saltpetre is common salt. In India this impurity has no commercial value as manure. A few samples from Bihar show a rather large percentage of sodium sulphate, and several of the inferior samples in the list contain excessive quantities of insoluble substances. The sample 730 from Bhawani appears to be adulterated with *khari* salt or crude sodium sulphate.

Impurities.

A practised eye can determine with fair precision the amount of nitre in a particular sample from the proportion of small elongated prisms peculiar to the alkaline nitrate as distinct from the granular or cubical crystals of the common salt. A refiner in Cawnpore during my visit was purchasing crude nitre from Rampur State and declared the sample to be superior and worth R3-8 a maund. The sample No. 384 was analysed and yielded 67·73 of potassium nitrate. The expert dealer was therefore right in his judgment. But

Composition of crude saltpetre

the prices quoted in the list of analyses do not indicate that they vary with quality in the way they ought to do. An uneducated, inexperienced cultivator would certainly be handicapped in buying supplies as manure, and without actual analysis it is difficult to suggest any practical form of protection. It is clear from the prices quoted by the officers of the Salt Department that the manufacturer of crude nitre would often be a gainer if a definite standard valuation was introduced. The same standard of valuation would not be suitable for very inferior and very superior samples, because a high percentage of common salt or other impurity would add to the cost of refining or add to the cost of transport. Ordinary samples of crude nitre apparently have from 40 to 64 per cent. nitrate of potash, and samples of this class would, at present

Valuation.

market rates, be worth at manufactories within easy distance of railways in the north of India, one anna per unit per maund for the percentage of potassium nitrate present. A sample containing 40 per cent. nitrate of potash would thus be worth 2-8 per maund, and samples containing 64 per cent. of nitre, R4 per maund. Samples containing under 40 per cent. nitre should be valued at less, and samples containing over 64 per cent. nitre at more, than one anna per unit. Crude saltpetre is cheapest just before the rains, being inferior owing to the conditions of temperature under which it is made. At this time refiners often buy extensively because crude saltpetre cannot be made during the rainy season.

It may be stated that crude nitre of high quality can be produced easily and cheaply from rich nitrous earth, but the nitrous soil of villages is the property of landholders and is rented out to saltpetre manufacturers. Rents vary with productiveness of soil. Matters are therefore equalized to some extent in this way. It has yet, however, to be determined whether crude nitre of high quality can be produced *economically* at existing market rates from the poorer qualities of nitrous earth. This is a matter for further enquiry.

STATEMENT II.—*Analyses of samples of crude saltpetre.*

Serial No.	Source of Sample.	Register No. of the sample in the office of the Agricultural Chemist.	Moisture.	Nitrate Potassium.	Chloride Sodium.	Sulphate Sodium.	Nitrate Calcium.	Nitrate Magnesium.	Insoluble.	Nitrogen.	Value at one anna per unit of Potassium Nitrate.	REMARKS.
1	2	3	4	5	6	7	8	9	10	11	12	13
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	R a.	
1	Shahawar, Etah, good quality	429	6·40	44·57	28·40	6·08	2·95	9·60	2·00	8·47	2 12	
2	" " middling	430	2·90	51·61	28·96	11·56	1·14	2·93	·90	7·86	3 0	
3	" " inferior	431	4·80	28·21	29·19	15·22	1·65	9·73	1·20	6·01	1 12	
4	Muttra, good	454	7·10	46·06	25·87	5·62	4·42	8·13	2·80	8·63	3 0	
5	" middling	455	4·70	39·52	37·63	3·40	4·92	2·93	6·90	6·83	2 8	
6	" inferior	450	7·80	50·57	27·04	3·06	4·10	6·13	1·30	8·82	3 0	
7	Hardoi, quality I, R4	868	6·90	64·22	19·14	2·16	2·62	3·56	1·40	9·97	4 0	
8	" " II, R3	869	5·30	55·58	27·84	3·84	2·62	2·92	1·80	8·64	3 8	
9	" " III, R2	870	7·00	44·58	6·96	17·20	4·56	3·20	16·50	7·52	2 12	
10	Farukhabad, quality I, R3-2	671	5·00	66·07	21·84	3·65	...	2·54	·90	9·58	4 0	
11	" " II, R3-2	873	4·30	65·84	22·04	4·36	1·96	...	1·50	9·41	4 0	
12	" " III, R1-13	874	3·70	44·92	35·38	10·00	...	4·80	1·20	7·10	2 12	
13	Gurwa, Ghazipur, superior, R3	674	8·90	47·32	28·56	3·16	4·56	6·40	1·10	8·48	3 0	
14	" " inferior, R2-8—R2	675	6·80	30·38	17·92	3·16	6·14	[illegible]·80	20·80	6·14	1 14	
15	Okara, Montgomery, Panjab, good	718	5·20	53·00	34·22	3·08	2·60	...	1·10	7·75	3 8	Described as good, middling and inferior, or 1st, 2nd, and 3rd quality.
16	" " " middling	719	6·50	43·98	44·66	2·92	tr.	1·04	·90	6·25	2 12	
17	" " " inferior	720	13·50	26·86	34·80	11·20	...	12·24	1·40	6·02	1 10	
18	Bhawani, Montgomery, Panjab, good	728	3·60	54·00	26·68	9·56	4·56	tr.	1·00	8·30	3 8	
19	" " " middling	729	5·30	41·78	35·38	9·24	1·96	2·64	3·70	6·59	2 8	
20	" " " inferior	730	7·90	35·96	19·72	30·92	1·28	4·12	2·10	5·67	2 0	
21	Hansi, Hissar, good	438	2·60	51·58	33·51	1·34	3·44	5·33	2·20	8·81	3 0	
22	" " middling	440	3·10	41·56	35·78	3·36	4·84	9·06	2·30	8·85	2 8	
23	Sirsa, Hissar, good	736	3·30	57·50	27·84	4·13	3·93	tr.	3·30	8·59	3 8	
24	" " middling	737	3·60	51·83	31·94	8·21	2·62	...	1·80	7·59	3 0	
25	" " inferior	738	7·10	43·49	27·26	8·22	4·59	4·24	5·10	7·58	2 12	
26	Shahpur, Panjab, good	743	9·30	39·22	31·90	5·60	5·24	2·64	6·10	6·71	2 8	
27	" " middling	744	8·00	44·81	28·42	5·08	5·15	4·24	4·20	7·87	2 12	
28	" " inferior	745	8·00	45·08	30·78	6·32	3·04	3·72	3·10	7·43	3 0	

STATEMENT II.—*Analyses of samples of crude saltpetre*—continued.

Serial No.	Source of Sample.	Register No. of the sample in the office of the Agricultural Chemist.	Moisture.	Nitrate Potassium.	Chloride Sodium.	Sulphate Sodium.	Nitrate Calcium.	Nitrate Magnesium.	Insoluble.	Nitrogen.	Value at one anna per unit of Potassium Nitrate.	Remarks.
1	2	3	4	5	6	7	8	9	10	11	12	13
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	R a.	
29	Andakilar, Saran, R2-8	751	9·30	42·40	37·70	3·40	1·28	5·32	·60	7·07	2 8	Valued at certain rates per maund of 82⅜ lbs.
30	Jahanabad, Saran, R2-12	752	6·10	57·42	26·68	9·20	...	...	·60	7·92	3 8	
31	Lalganj, Saran, R3	753	7·50	48·42	39·44	4·64	...	tr.	4·64	6·68	3 0	
32	Muzaffarpur, Saran, R2	767	7·00	49·36	16·82	14·60	3·28	7·44	1·50	8·77	3 0	
33	Mahgaon, Allahabad, R2-8	713	9·10	59·72	22·04	2·16	1·28	4·80	·90	9·36	3 8	
34	Shahzadpur, Allahabad, R2-8	714	5·80	65·56	25·52	...	...	3·12	...	9·64	4 0	
35	Allahabad (solar process, filters)	712	15·20	35·02	30·70	5·84	tr.	12·24	...	7·15	2 0	Manufactured by means of solar heat.
36	Hamirpur (solar process) R2-8	702	5·20	79·70	5·80	2·16	5·24	tr.	1·90	11·88	5 0	
37	Chak, Jalaun (solar process) R2-8	708	7·10	55·80	26·10	2·68	4·56	1·76	2·00	8·80	3 8	
38	Dumraon Farm	269	5·06	53·74	34·08	2·96	2·29	tr.	1·87	7·79	3 8	Ordinary commercial samples used as manure by Government farms and also obtained direct from manufacturers.
39		863	7·30	55·30	33·06	1·68	1·96	...	·70	7·96	3 8	
40	Burdwan „	321	6·92	53·51	28·08	2·43	4·92	...	4·14	8·20	3 8	
41	Rampur State	384	2·40	67·73	19·31	4·02	1·31	4·13	1·10	10·34	4 0	
42	Siripur	545	4·90	33·73	22·34	10·73	5·90	4·80	9·60	6·51	2 0	
43		651	12·70	40·36	14·70	2·68	12·26	5·60	11·70	8·70	2 8	
44		849	9·40	37·16	11·02	18·42	7·84	1·76	14·40	6·78	2 4	
45		879	10·40	46·46	8·12	15·60	7·20	2·12	10·10	8·03	3 0	
46		850	11·80	45·08	6·38	14·60	7·84	1·60	12·70	7·85	2 12	
47	Marh, Saran	659	4·40	58·20	22·34	3·90	3·92	2·64	4·60	9·19	3 8	
48	Hakwa, Saran	662	6·20	54·00	25·20	2·92	5·24	2·64	3·80	8·10	3 8	
49	Dokra, Bihar	765	7·20	62·60	23·78	2·40	1·28	2·64	·10	9·34	4 0	
50	Barhanpura, Saran	766	3·80	68·40	17·98	3·40	2·60	2·12	·70	10·27	4 4	
51	Kheora, Cawnpore	390	3·80	47·67	28·96	8·64	1·80	7·33	1·80	8·26	3 0	
52	Malon, Kheora, Cawnpore	306	2·10	75·39	17·60	1·08	·80	2·53	·50	11·01	4 12	
53	Alinagar, Benares	693	5·10	76·47	11·76	3·16	1·31	1·60	·60	11·07	4 12	
54	Fatehpur, Allahabad	696	9·20	73·79	6·16	2·43	2·60	5·32	·50	11·63	4 8	
55	Gujrat, Panjab	819	5·00	63·20	26·32	2·43	1·31	1·04	·70	9·07	4 0	

The Refining of Saltpetre.

The refining of saltpetre

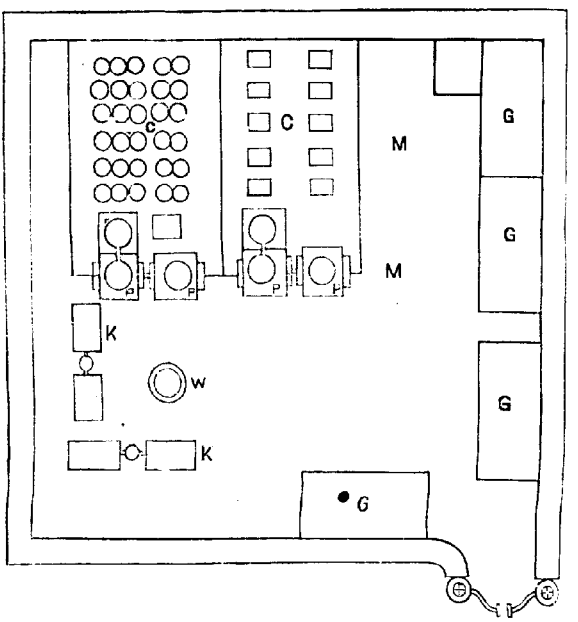
A saltpetre refinery consists of a large fenced yard with office and godowns and sheds for the factory occupying sometimes several acres of land. One portion of the yard is covered with earth suitable for crude nitre production. When a refinery is first established nitre earth is obtained and spread on a part of the yard. The salt from the nitrous earth obtained from this area is extracted in the ordinary way with water, and the exhausted earth is spread out on this portion of the yard to receive the furnace ashes and nitrous by-products from time to time. The ashes, soil, and washings are mixed intimately, and fresh nitre is constantly generated from the "factory soil." It is a common opinion that such earth is better than new earth collected from outside. At any rate it is a continual source of crude nitre to the refiner, and it enables him to use to the best advantage all the products of his factory which otherwise might be wasted.

Description of refinery.

The accompanying is a sketch of a refinery at Jajmow, Cawnpore, in the United Provinces. The yard is enclosed with a high mud wall and gate. One portion of the yard (M) is covered as described above with *lunamatti* or nitre earth. At the left corner there are two pairs of filters or *kuriat* (KK) for extracting crude nitre from nitrous earth. A well (W) supplies the water for this process as well as for making solutions for the refining process. There are four iron evaporating pans (PPPP) supported on masonry fire-places. Here the nitre liquor is boiled. Near each pan is another empty pan or wooden vessel to serve as a settling tank. From this the liquid is transferred to the crystallising tubs (C) arranged under the sheds. These tubs are so arranged that each day as two or more are filled, two or more are emptied, and the crystals collected. The round tubs are for making crude nitre or small refined crystals, the larger oblong vessels are for the production of the higher quality or *kalami* saltpetre. One of the most important utensils in the refinery is a boiler or iron pan for evaporating the liquor. The pan is from 10 to 12 feet in diameter, and costs R260; if well made, one will last ten years. It is supported on a brick-and-chunam furnace, which is 25 feet long, 15 feet broad, and 4 feet deep. Two sloping slides enable men to carry the crude nitre to the pan. In the front is the door of the furnace. At the other end nearest the sheds is a cistern of solid masonry or a spare pan. Under the sheds are arranged the crystallising vessels, which are wooden oblong tanks 7 feet long, 5½ feet broad, and 2 feet deep, where the nitre crystals form.

Refining of saltpetre.

The process followed varies in different refineries and in different parts of the country. But as the chloride of sodium is the principal impurity and as its solubility is practically constant, all the processes followed are based on the varying solubility of nitrate of potassium in hot and cold solutions.



To start a refinery, the nitre earth obtained from the factory soil is filtered in the two pairs of *kurias*. The crude nitre solution obtained from these is boiled down, clarified by sedimentation and set out to crystallize. In from six to ten days the crystals are extracted and the residual *lor* or mother-liquor is then available for future use. Crude saltpetre is dissolved in this mother-liquor to which sufficient water or washings are added to keep up the volume. The main supply of crude nitre is obtained by purchase from small manufacturers. A well near the centre of the yard supplies sufficient water,

usually of a saline character for the operations. When crude nitre is dissolved in *tor* or mother-liquor and the solution is concentrated by boiling in the large evaporating pans, a dirty white granular substance known as *sitta* falls to the bottom of the pan. The *sitta* as it forms is removed by means of a large iron spade fixed to a handle 6 feet long. The *sitta* thus obtained is sometimes washed and the washings are returned to the pan. In Behar, where *sitta* is not excised, it is mixed with the refinery earth. About 2½ maunds of *sitta* is separated from each pan of liquor. At a factory near Cawnpore the proportion of *sitta* was said to be 20 per cent. of the crude saltpetre.

Refining of saltpetre.

Sitta.

The evaporation of the liquid in the pan is continued at the temperature of boiling water. In some factories the froth or scum, called *zag*, *zoga*, *mail* or *phain*, is removed from the surface at this stage, in others it is removed after transfer to the settling tank. After boiling for three hours, or until the liquid changes from a dark to a light yellow colour, the concentration is considered complete. The liquid is emptied out of the pan by means of an iron scoop known as a *dal* hung at four corners by ropes. Two men stand on opposite sides each holding two ropes. They deftly raise the liquid in the *dal* from the pan and pour it into the wooden trough which leads it to the settling tank. Here the hot liquid is allowed to settle for about 2 hours. The scum or *zag* is taken off with an iron perforated *jhara*, and the clarified liquor is decanted, or syphoned off with a bent brass tube, into one or more crystallising vats. At the bottom of the settling tanks is found a substance called *matiaree*, which is a by-product containing nitrates, and is accordingly carried off and mixed with the nitrous earth in the factory yard. The crystallising vats under the sheds are filled with nitre liquor to about 6 inches from the top. In the United Provinces on the surface of each is floated a trellis work made of interlaced bamboo sticks (called *tattis* in Cawnpore). This device facilitates the formation of good crystals. After seven days the bamboo frames are removed and the adhering nitre crystals are shaken or picked off, and the crystals at the bottom and sides of the trough collected into a heap and drained. At Kheora, Cawnpore, troughs of two sizes are used. There are some 3 by 5 feet, which require the liquor to remain eight days, and others, 6 feet square, where the liquor remained ten days. The larger the vessels and the longer the liquor stands, the larger and longer are said to be the crystals.

Scum.

Crystallising.

The damp saltpetre is contaminated with the mother-liquor adhering to it, and minute crystals of salt, and these must be removed by washing before the salt is ready for the market. Plain water is

Refining of saltpetre.

used for this purpose. Alum is occasionally used for the same purpose as indigo blue to whiten the saltpetre. Alum is also used in admixture with saturated nitrous liquor before it is run into the crystallising vats, in order to precipitate matter in suspension in the liquid. Bags containing the refined substance are placed over an empty tub or vat which is slightly tilted to allow the liquor to drain. Cold water is sprinkled from time to time upon the saltpetre through the open mouth of each bag. This water trickles slowly through the saltpetre crystals carrying with it inferior salts in solution. Some saltpetre is also dissolved but the loss is not great. After the washing the refined saltpetre is spread out and dried, and after remaining a few hours is conveyed to the store godown.

Tor.

The mother-liquor or *tor* from the crystallising vats and all washings of the refined saltpetre, and of the settling and setting vats and of *silta* are returned to the evaporating pans and used for dissolving fresh crude nitre. It is thus seen that the utmost economy is practised at every stage of the refining processes, and, practically speaking, no nitrate is wasted.

One evaporating pan is capable of dealing with two boilings (40 maunds of crude nitre) per day. The boiling begins early in the morning and is finished by midday. It is calculated that one maund of crude nitre according to its quality will yield from 15 to 23 seers (37·5 to 57·5 per cent.) of refined nitre.

Fuel.

The fuel used at Hansi is cotton stalks, and costs R1 per day. At other factories other cheap fuel, such as dried castor stalks and wild shrubs, is used.

The total output from the refinery described is 2,800 to 3,000 maunds in a season, but the output from any refinery will vary with the quality of the crude nitre. The list of analyses indicates that the quality is very variable.

Government regulations.

A Government license costing R50 is required. The owner is required to keep regular records of all production and purchases of crude saltpetre, the quantity of refined saltpetre produced, and of the *silta* and salt, and details of issues. He is also required to submit weekly returns to the Assistant Commissioner of Northern India Salt Revenue. Officers of the Salt Department visit these refineries whenever they wish in order to check the records, inspect the premises, and see to the removal under the rules and on payment of duty of any salt or *silta* the owner may desire to excise for sale or to the destruction of any salt or *silta* the owner may apply to have destroyed. *Silta* contains a large proportion of common salt, and if removed for sale the nitre refiner is compelled to pay a tax of R1 a maund.

STATEMENT III.—*Analyses of refined saltpetre.*

Serial No.	Source of Sample.	Register No. of sample in the office of the Agricultural Chemist to the Government of India.	Water.	Potassium Nitrate.	Sodium Chloride.	Sodium Sulphate.	Calcium Nitrate.	Nitrogen in Nitrates.	Remarks.
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
1	Jajmou, Cawnpore, *kalami*	388	1·50	97·37	1·13	...	tr.	13·44	
2	„ „ unwashed	385	3·23	92·83	3·97	...	tr.	12·69	Ordinary samples of refined saltpetre.
3	Kheora (1), Cawnpore	393	·30	91·34	7·52	·84	tr.	12·60	
4	„ (2), „	399	·10	93·74	5·68	·48	tr.	12·93	
5	Hissar, Hansi, Panjab	437	·70	94·92	3·40	·48	tr.	13·09	
6	Siripur, Saran, No. 1	548	1·00	90·16	7·64	·60	tr.	12·44	
7	Dindialpur, Saran, refined	657	3·90	82·68	10·58	1·68	·66	11·52	
8	Sewan, Saran, *kuthia*, refined	931	4·60	89·80	4·64	·96	...	12·37	
9	Bans Deeh, *kuthia*	688	4·20	90·16	3·92	tr.	1·72	12·73	
10	Okara, Montgomery, Panjab	723	3·70	92·68	2·90	·72	...	12·78	
11	Barhanpura, Bihar, refined	770	5·30	90·64	4·06	...	...	12·50	
12	„ „ washed	771	4·10	94·16	1·74	..	...	12·99	
13	Shahzadpur, Allahabad, ₹6	711	4·20	93·46	1·74	...	...	12·89	Samples of ordinary refined saltpetre and *kuthia* saltpetre, with market rates for each sample.
14	Bidakhar, Hamirpur, ₹5	704	2·60	89·86	7·54	...	...	12·40	
15	Lalganj, Saran, ₹5-8	754	3·10	92·00	1·74	3·16	...	12·69	
16	„ „ *kuthia*, ₹4	755	4·30	74·42	16·24	2·40	2·64	11·76	
17	Barhanpura, Bihar, *kuthia*, ₹4	708	4·70	74·96	19·14	1·20	...	10·34	
18	Dindialpur, Saran, *kuthia*	656	2·80	74·08	19·40	1·96	1·74	10·55	*Kuthia* saltpetre.
19	Sewan, Saran, *kuthia*	930	3·80	75·90	18·56	1·68	...	10·47	
20	„ „ washed, *kuthia*	932	2·10	91·02	5·22	·96	...	12·56	
21	Gorakhpur, *kuthia*	687	4·70	85·50	7·84	tr.	1·96	12·12	
22	Cawnpore Farm	350	7·70	83·09	8·42	·79	...	10·51	Samples used as manure at the Cawnpore and Nagpur Farms.
23	„ „	908	2·60	77·24	18·56	tr.	1·60	10·95	
24	Nagpur Farm, ₹4-8	441	·10	84·25	11·36	·85	·82	11·75	
25	Siripur, Saran, No. 2	549	1·60	65·22	32·34	·84	tr.	9·00	Adulterated sample.

Composition of refined saltpetre.

The Composition of Refined Saltpetre.

In Statement III the analyses of twenty-five samples of refined saltpetre are arranged in five groups. The reason for grouping is indicated by the headings. Refined saltpetre is called by the manufacturers *kalami shora*, and the analysis shows that the native refiner in this country with his ordinary arrangements can turn out refined saltpetre practically pure. The first sample on the list was perhaps extra carefully refined. The second analysis is of crystals from the same batch which were dried without washing.

The impurities present in refined saltpetre are chlorides and sulphates of potassium and sodium, moisture and insoluble substances.

The first twelve analyses on the list show that samples which are refined in a reliable way are generally of fairly high standard of quality.

The market rates are given for the next five samples on the list, and these indicate that the relation between quality and actual value is fairly recognised in the case of refined saltpetre.

Kuthia saltpetre.

The two last samples of this group and the four samples of the next group are called by refiners *kuthia* saltpetre. The term is derived from filters which in Bihar are called *kotis*. This is a white salt which crystallises with a large proportion of chlorides varying in the samples from 7·8 to 19·14 per cent. It is made by evaporating nitrous brine obtained from filtering the refinery earth. *Tor* or mother-liquor is sometimes added.

The samples of the next group were used as manure at the Cawnpore and Nagpur Farms. They are more akin to very good samples of crude nitre than to refined nitre. The Nagpur sample costs ₹4-8 per maund at Cawnpore and ₹6 per maund landed at Nagpur, and is not dear at the price. The last sample on the list has obviously been adulterated. It should be noticed that the samples used as manure this year at the Dumraon, Siripur, and Burdwan Farms were distinctly crude and very dear, which proves that buying in the bazar is more or less a lottery.

Saltpetre for gunpowder.

When required for the manufacture of gunpowder saltpetre must possess a high degree of purity. At the Ishapur Factory where until within the last two years gunpowder has been made for Indian consumption, saltpetre "grough" is purchased from Bihar and further refined at the powder factory until a crystal of saltpetre will dissolve in a solution of silver nitrate without producing a cloudiness. A sample of the "grough" bought by the Superintendent, afforded the following analysis:—Insoluble ·08, water 1·97, sodium chloride ·69,

sulphate potassium ·04, or a refraction of 2·78 per cent., leaving 97·22 per cent. of potassium nitrate. Composition of refined saltpetre.

An advertisement recently appearing in the *Government of India Gazette*, for a tender of 10,000 cwts. of saltpetre for use in the cordite factory at Wellington, specified the following limitation of impurities:—"It must contain not less than 95 per cent. potassium nitrate and not more than 0·85 per cent. of chlorides, calculated as sodium chloride determined by analysis of the dried saltpetre." 9th July 1902.

Having now shown the nature of the impurities naturally associated with saltpetre, and after discussing the method of their removal, it only remains to give the ultimate composition. The chemical formula of saltpetre is KNO_3, and in the absolutely pure salt the elements are combined in the following proportion:—

Potassium 38·62, Nitrogen 13·86, Oxygen 47·52 = 100·00

The price of refined nitre was last season R5-8 to R6 per maund in Bihar and Hissar, and R8 in Cawnpore, and that of extra good quality with large crystals R9 at Cawnpore.

Sitta and Common Salt.

Sitta.

The Inspector General of Agriculture caused particulars to be collected regarding the use and trade in the common salt educed in the saltpetre refineries. Sodium chloride is a constant ingredient in nitrous earth, and constitutes the chief impurity of crude saltpetre. During the concentration of the nitrous liquor by boiling, it is thrown out of solution in considerable quantity and is afterwards easily divested of its impurities. The cause of this deposition is owing to the difference in the solubility of the two salts with the rise of temperature. A quantity of nitrous mother-liquor, saturated in its cold state with saltpetre and chloride of sodium, is placed in a boiler and heated to the boiling point, a little water having been added to it to maintain it in full quantity while being heated. Crude saltpetre is then thrown into it, the nitrate of potassium is taken up in the liquid in solution, and the chloride of sodium with other impurities remains undissolved at the bottom of the boiler and is removed. This undissolved matter is true *sitta*. It is composed for the greater part of common salt mixed with other salts, earth and nitrogenous matter. A similar substance is produced when crude saltpetre is dissolved in mother-liquor diluted by the mixture of nitrous brine from the refinery filters. In such case the chloride of sodium is all dissolved, but is again precipitated when the solution is concentrated to the saturation point of saltpetre. Removed in admixture with earthy and other impurities this impure salt is very

Sitta.

like true *sitta* and is classed as such, impure and inedible saltpetre salt.

In the tabulated analyses of fourteen samples of *sitta* from the Panjab, United Provinces, and Bengal, the percentage of alkaline chlorides varies between 26·68 and 72·5. The sample (No. 486) from Hansi, Hissar, was collected from the drain in the factory where it had been destroyed by mixing with earth and water. The saline matter was recovered in the laboratory at Dehra Dun and afterwards analysed. The separated salt contained 85·2 per cent. of pure sodium chloride with small amounts of sulphates and nitrates.

A tax of R1 a maund is paid for excising *sitta* from refineries in the Panjab, and in the Agra and Farukhabad circles of the United Provinces. The fee was raised from 8 annas to R1-0-0 with effect from 1st July 1901, as there was some reason for supposing that the concession was being abused. In Hansi it is said the selling price is so little above the tax paid for it that it is not worth keeping for sale, hence it is destroyed. In other places *sitta* is occasionally sold for preserving hides and dressing leather. It is also used for preserving coarse beef intended for export to Burma. But in most factories where impure salt is separated it is never sold to the public but is converted into alimentary salt.

Uses of sitta.

Edible salt.

To educe edible salt crude saltpetre is thrown into a liquid sufficiently poor in saline matter to take up all of the salts in solution. When the concentration of the liquid approaches the precipitation point of salt, it is removed to a settling vat and impurities in suspension are allowed to subside. It is finally put back into the boiler and further concentrated until salt precipitates and can be removed. The purification of *sitta* (impure salt) is generally effected by dissolving it in nitrous brine. The solution is clarified by sedimentation in the settling vat, the clear liquor is returned to the boiler, *tor* or mother-liquor is added, and salt is educed by concentrating the mixture.

A Government tax of R1-8 has to be paid by the refiner for each maund of common salt made in his factory, and it is sold at the rate of R1-9 to R1-12 per maund.

A table of analyses, Statement IV, is appended showing the composition of *sitta*. The following table, Statement V, gives the analyses of fourteen samples of *sitta* made by **Dr. J. Walter Leather**, Agricultural Chemist to the Government of India. It will be noticed that in some instances a large proportion of the chloride exists as a potassium salt.

STATEMENT IV.—*Analyses of Impure Salt (Silta).*

Register No. of sample in the office of the Agricultural Chemist to the Government of India.	Source of Sample.	Moisture.	Alkaline Chlorides.	Sodium Sulphate.	Nitrates and other salts.	Insoluble.
386	Jajmou, Cawnpore .	2·80	71·00	6·40	13·60	6·20
391	Kheora (1), Cawnpore .	5·40	58·50	4·93	29·07	2·10
397	,, (2), ,, .	1·90	57·93	7·61	18·66	13·90
428	Etah	7·20	51·12	11·44	27·54	2·80
453	Muttra . . .	7·60	64·68	7·92	17·70	12·20
486	Hansi, Hissar . .	3·30	85·20	4·66	6·84	...
666	Hardoi, R1-2 . .	5·70	59·92	3·41	26·77	4·20
670	Farrukhabad, R1-2 .	2·80	70·00	5·56	17·04	4·60
21	Okara, Panjab . .	7·00	72·50	3·64	14·76	2·10
731	Bhawani, Panjab . .	6·10	59·16	19·24	13·90	2·60
739	Sirsa, Hissar, Panjab .	7·60	49·88	16·80	21·12	4·60
746	Shahpur, Panjab . .	6·20	70·68	4·12	16·50	2·50
757	Lalganj, Saran . .	9·40	30·16	18·76	29·08	12·60
773	Ramchandarpur, Muzaffarpur.	7·80	26·68	38·24	19·38	7·90

SALTPETRE. **A Report on the Manufacture and Composition**

STATEMENT V.

	1318-04.	1319-04.	1320-04.	1321-04.	1322-04.	1323-04.	1324-04.	1325-04.	1326-04.	1327-04.	1328-04.	1329-04.	1330-04.	1331-04.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Sitta - Impure salt by-product of a saltpetre refinery—Sikandra Rao, Aligarh District.	Sitta—Impure salt by-product of a saltpetre refinery—Farukhabad.	Sitta—Impure salt by-product of a saltpetre refinery—Farukhabad (*Note I*).	Sitta—Impure salt by-product of a saltpetre refinery—Muttra.	Sitta—Impure salt by-product of a saltpetre refinery—Produced at Sirsa-Hissar.	Sitta—Impure salt by-product of a saltpetre refinery at Khoie, Ferozepore.	Sitta · About 80 per cent. chloride of sodium. Impure saltpetre salt by-product of a saltpetre refinery, Okarar, Montgomery.	Sitta—About 80 per cent. sodic chloride. Impure salt by-product of a saltpetre refinery Farukhabad.	Sitta—About 80 per cent sodic chloride. Impure salt by-product of a saltpetre refinery—Ghatia-ghat Farukhabad.	Sitta—Produced at Laldarwaza refinery—Farukhabad.	Sitta—About 80 per cent. sodic chloride. Impure salt by-product of a saltpetre refinery Bakramow, Farukhabad.	Sitta—Monghyr Circle.	Sitta—Patna Circle.	Sitta—Saran Circle.
Potassium Nitrate . .	10·78	14·49	13·04	14·90	13·78	12·48	2·67	4·84	11·16	12·39	6·70	14·22	8·20	4·35
" Sulphate. .	6·70	8·72	8·03	3·68	11·09	24·47	6·71	5·96	8·98	7·03	6·90	21·40	21·10	6·46
" Chloride . .	28·27	19·90	9·06	22·97	3·40	...	3·11	...	23·88	24·42	26·11	...	...	...
Sodium Sulphate . .	...	...	...	...	...	·78	...	5·60	...	...	...	2·62	5·14	6·64
" Chloride . .	43·01	42·08	58·85	35·80	60·24	40·17	77·70	74·33	39·14	43·20	46·75	36·71	44·52	42·56
Water	6·70	10·64	7·63	15·72	3·42	8·22	·39	5·98	11·54	9·07	9·86	10·84	6·31	6·38
Organic matter . .	·34	·02	·11	·18	·34	·64	·31	·21	·39	·18	·21	·87	·70	·96
Sand	3·15	1·54	2·34	5·29	6·10	13·39	8·15	·95	1·95	2·66	2·04	12·06	13·16	31·29

Note I.—This is more saline than the ordinary "*Sitta*" produced in the Farukhabad Refineries.

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Saltpetre salt.

In Statement VI the analyses of twenty samples of refinery or saltpetre salt are shown. The samples were obtained from Northern India and Bihar. The percentage of chloride varies from 69·44 per cent. in an illicit sample from Sewan to 97·2 per cent. in a sample obtained from Montgomery, Panjab. More than half the samples contained over 90 per cent. Some of the samples are clean and white, and the crystals are dry and uniform. There is nothing injurious to health in the composition of the best samples. Those containing high percentages of nitre might be viewed, however, with some suspicion for household purposes.

The actual values of certain samples were given by officers of the Salt Department, and the analyses show that the prices vary in accordance with the quality.

STATEMENT VI.—*Analyses of Refinery Salt.*

Register No. of sample in the office of the Agricultural Chemist to the Government of India.	Source of Sample.	Moisture	Alkaline Chlorides.	Sodium Sulphate.	Nitrates and other salts.	Insoluble.
387	Jajmou, Cawnpore .	2·20	93·15	...	4·65	..
392	Kheora (1) „ .	·70	95·42	1·34	2·54	...
398	„ (2) „ .	2·80	94·52	2·68	...	...
426	Etah, good quality .	1·80	85·20	3·02	9·93	·70
427	„ inferior „ . .	2·90	76·11	9·38	11·11	·50
451	Muttra, good quality .	1·10	96·68	1·08	1·14	...
452	„ inferior „ . .	4·70	78·79	3·52	12·79	·20
652	Sewan, Saran, *kuthia* .	1·40	95·85	·24	3·11	...
653	„ „ *dhulia* .	1·40	96·43	·48	1·69	...
658	Dindialpur, Saran, *kuthia*	1·00	92·22	1·68	5·10	...
661	Sewan, Saran (Illicit) .	7·20	69·44	8·22	11·44	3·70
867	Hardoi, superior, R2-10 .	2·60	92·12	1·68	3·10	·50
665	„ inferior, R2-9 .	3·40	86·24	4·40	5·96	...
668	Farukhabad, superior, R2-14-6.	1·90	95·51	1·95	·04	...
669	Farukhabad, inferior .	5·50	82·88	6·82	3·69	1·10
676	Gurwa, Ghazipur, R2-10—R3.	1·60	64·03	1·21	2·26	·90
724	Okara, Montgomery, Panjab.	2·80	97·20	tr.	tr.	...
756	Lalganj, Saran . .	6·90	75·98	9·00	8·12	...
772	Parsanni, Muzaffarpur .	2·90	89·90	2·64	4·26	·30
774	Mankapur, „ (Illicit)	2·80	84·10	7·28	4·80	1·40

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By-products.

Other By-Products.

Except *silla*, and the common salt made from it, the by-products of the refinery are not of very great importance. The scum which forms on the surface of the boiling nitre liquor is called by various names, such as *zag, zoga, mail,* and *phain*. Samples of this product from Kheora and Hansi have been examined, and they have been found to consist chemically of potassium, magnesium and calcium salts, combined as chloride, sulphate and nitrate. These salts were combined with organic matter derived from vegetable débris; the scum is a mixture of crystalline salts and vegetable or organic remains. It contains nitrates mostly of calcium and magnesium.

The two samples were composed as follows—

	Kheora.	Hansi.
Water	3·90	5·40
Loss on ignition	20·85	22·10
Sodium chloride	51·97	35·28
Sodium sulphate	4·57	3·29
Nitrates of potassium, calcium and magnesium	18·71	33·93
	100·00	100·00

Mattiaree.

Mattiaree is the Hansi name of the deposit left at the bottom of the settling tank when the nitre liquor has been decanted into the crystallising vats. This consists for the most part of sulphate of calcium, chloride and nitrate of potassium, calcium and magnesium.

Mattiar.

Mattiar in Bihar is the name of the residual nitrous earth left after the process of leaching.

Trade.

Trade.

As regards the trade in saltpetre, the subjoined tabulated statement of quinquennial averages compiled by the Commissioner, Northern India Salt Revenue, shows what the exports from India have been during the past 50 years.

	Average annual export, cwt.	Average value per cwt. R	a.	p.
1853-54—1857-58	606,624	7	14	1
1858-59—1862-63	631,281	10	17	7
1863-64—1867-68	417,895	11	8	3
1868-69—1872-73	464,253	8	15	4
1873-74—1877-78	454,965	9	2	2
1878-79—1882-83	399,839	9	10	7
1883-84—1887-88	425,945	9	6	2
1888-89—1892-93	815,107	9	9	11
1893-94—1897-98	408,585	11	0	8
1898-99—1902-03	374,810	9	15	0

Trade.

In 1859 a duty of 3 per cent *ad valorem* was imposed on the export of saltpetre. This light tax did not affect the trade prejudicially, though there was some rise in price. In 1860-61 an export duty of R2 was levied and this was maintained until 1864-65. This heavy duty was severely felt, and in consequence of its imposition, prices rose considerably, and the trade declined. In 1865-66 the duty was reduced to one rupee per maund, and this was followed next year by a reversion to the 3 per cent. *ad valorem* rate. In the following year (1867-68) the duty was entirely removed, but the trade was unable to recover from the effects of the high rate of duty levied during the six years from 1860-61 to 1865-66. The failure of the trade to recover its former position was probably due to the fact that the high prices imparted a stimulus to scientific enquiry for substances which might supersede the use of natural saltpetre, and this led to the production of saltpetre artificially from the decomposition of sodium nitrate and potassium chloride. Again the manufacture of high explosives such as cordite has largely tended to depress the use of black powder in warfare, sport and blasting.

Effect of duty.

Artificial saltpetre.

Under these circumstances the Indian saltpetre trade has held its own better than might have been expected. There has been a decline in the export during the past few years, but the trade is subject to fluctuations and a revival is possible at any time. The Director General of Statistics in 1902 pointed out that the Indian market is affected favourably or unfavourably by the fluctuations in the artificial saltpetre trade to which it responds. If the competition of artificial saltpetre did not exist, the Indian trade would be steady and progressive despite the excise system. It has been remarked that the Indian trade has been depressed within recent years owing to the increased use in the United Kingdom and America of bone manure which seems to be taking the place there of nitrous manures. But this explanation is not conclusive.

In the Far East the exports of Indian saltpetre to China have grown steadily up during the same period. In Japan, however, owing to cheap freight and the fact that German artificial saltpetre is admitted at half the rate of duty than the Indian commodity has to pay, the exports from India during the quinquennial period 1896-97—1900-01 have fallen from 246 to 61 tons.

The total exports of saltpetre from British India during the five years ending with 1900-01 amounted to 2,055,267 cwt., while the registered production for the same period in Northern India and Madras was 2,046,899 cwt. (2,786,058 maunds). Even allowing for

stocks held previously and for errors in registration it would appear that the demand for saltpetre in the country is comparatively small, and that the industry is regulated almost entirely by the requirements of foreign trade.

Saltpetre manufacturers.

List of Leading Manufacturers of Refined Saltpetre in the Panjab, the United Provinces, and Bihar.

1. Behari Lal, Mohalla Lal Darwaza, Post Office Farukhabad, District Farukhabad (United Provinces).
2. Bolaki Das, Mohalla Wrightganj, Post Office Farukhabad, District Farukhabad (United Provinces).
3. Pirag Das, Mohalla Bakramow, Post Office Farukhabad, District Farukhabad (United Provinces).
4. Gopi Nath Badri Das, Mohalla Ghatiaghat, Post Office Farukhabad, District Farukhabad (United Provinces).
5. Gokal Chand, Mohalla Khanpur, Post Office Farukhabad, District Farukhabad (United Provinces).
6. Gurmuk Rai Durga Pershad, Village Jajmou, Post Office Cawnpore, District Cawnpore.
7. Baigu Lal, Village Raipur, Post Office Akbarpur, District Cawnpore (United Provinces).
8. Sham Lal, Village Hardoi, District Hardoi (United Provinces).
9. Chotey Lal, Village and Post Office Khyrabad, District Sitapur (United Provinces).
10. Bhai Lall, Village and Post Office Seramow, District Shahjahanpur (United Provinces).
11. Sheo Narain, Village and Post Office Sirsa, District Hissar (Panjab).
12. Ramji Das, Village Khaie, Post Office Ferozpore, District Ferozpore (Panjab).
13. D. McLeod, Village and Post Office Okara, District Montgomery, (Panjab).
14. Ramnarain, Village Sohagpur, Post Office Hathwa, District Saran (Bihar).
15. Lachmi Pershad, Village Dataganj, Post Office Chapra, District Saran (Bihar).
16. Saligram Mehto, Village Devaria, Post Office Enai, District Saran (Bihar).
17. Sheikh Mehbcob Raza, Village Savan, Post Office Savan, District Saran (Bihar).
18. Khoob Lal, Village Bhatolia, Post Office Paroo, District Muzaffarpur (Bihar).
19. Raikharam, Village Karnawl, Post Office Sahibganj, District Muzaffarpur (Bihar).
20. Bhondoolal, Village Raini, Post Office Sakra, District Muzaffarpur (Bihar).

21. Musst. Bholia, Village Surmastpur, Post Office Chandanputti, District Muzaffarpur (Bihar).
22. Gokhal Sahu, Village Surmastpur, Post Office Chandanputti, District Muzaffarpur (Bihar).
23. Beharilal Sahu, Village Pursal, Post Office Katra, District Muzaffarpur (Bihar).
24. Kewalput Sahu, Village Pursal, Post Office Katra, District Muzaffarpur (Bihar).
25. Narain Sahu, Village Bundhu Patti, Post Office Kamtoul, District Darbhanga (Bihar).
26. Ram Lal, Village Bundhu Patti, Post Office Kamtoul, District Darbhanga (Bihar).
27. Doma, Village Gobindpur Behta, Post Office Darbhanga, District Darbhanga (Bihar).
28. Dwarka Pershad, Village Mow, Post Office Mow Bazidpur, District Darbhanga (Bihar).
29. Laltapershad Jhabbu Lal & Coy. Sekandra Rao, Aligarh.

Saltpetre as a Manure.

Saltpetre as a manure.

Nitrous earth is used as a manure by cultivators in tracts where there is an available local supply. In Bihar cultivators employ it as a fertilizer in poppy cultivations. In the United Provinces, cultivators utilize as much as they can obtain for wheat, potatoes and other crops. In the Tinnevelly District of Madras, nitrous earth is employed as a manure for tobacco, millets and garden crops. Dr. Leather in three samples of this earth found 78, 1·05 and 1·78 per cent of potassium nitrate. Many trials of crude saltpetre alone, and in combination with bone-dust and superphosphate, have been made at Government Experimental Farms. At the Cawnpore Farm, twenty years' experiments have shown that saltpetre increases the yield per acre of maize from 740 to 1,020 lbs. and of wheat from 1,270 to 1,710 lbs. (see N.-W. P. Bulletin No. 9 of 1900). Similar experiments at the Nagpur Farm have given an increased yield per acre of wheat from 420 to 870 lbs. At the *Dumraon* farm, saltpetre has increased the yield of paddy from 950 to 1,440 lbs. per acre, and has given good results for wheat (see *Agricultural Ledger* No. 10 of 1893). The best results have been obtained from twelve years' experiments at the Burdwan Farm, where saltpetre has increased the yield of paddy from 1,480 to 4,350 lbs., giving a profit of Rs. 105 per acre for an outlay of Rs. 9-4 on saltpetre. It has also given excellent results when tried upon jute and sugarcane. Experiments at Poona and Surat have also shown that saltpetre is a successful manure for rice. Saltpetre has thus almost uniformly proved itself directly valuable as a manure for cereal crops, which was to be expected when the average refined

Saltpetre as a manure.

material contains about 12 per cent of nitrogen and 43 per cent of potash. With an advance of agricultural methods, there should be a considerable expansion in the use of saltpetre as a fertilizer, but under present conditions its extended use is hampered by its price, the cost of railway freight over long distances and the fact that there is no guarantee as to its purity. Indian saltpetre (potassium nitrate) is more valuable than Chili saltpetre (nitrate of soda) in various industries, so that its price is regulated by the export trade and is independent of agriculture.

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G. I. C. P. O.—No. 1401 R. E. P.—19-9-1905.—2,500.—P. M. M.